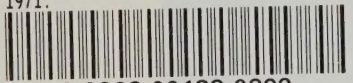
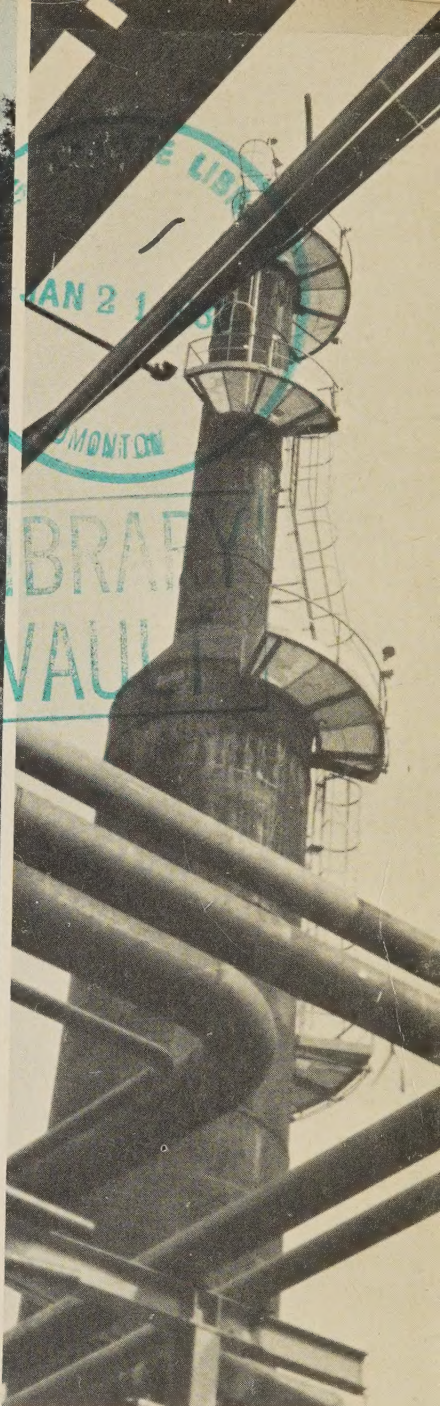
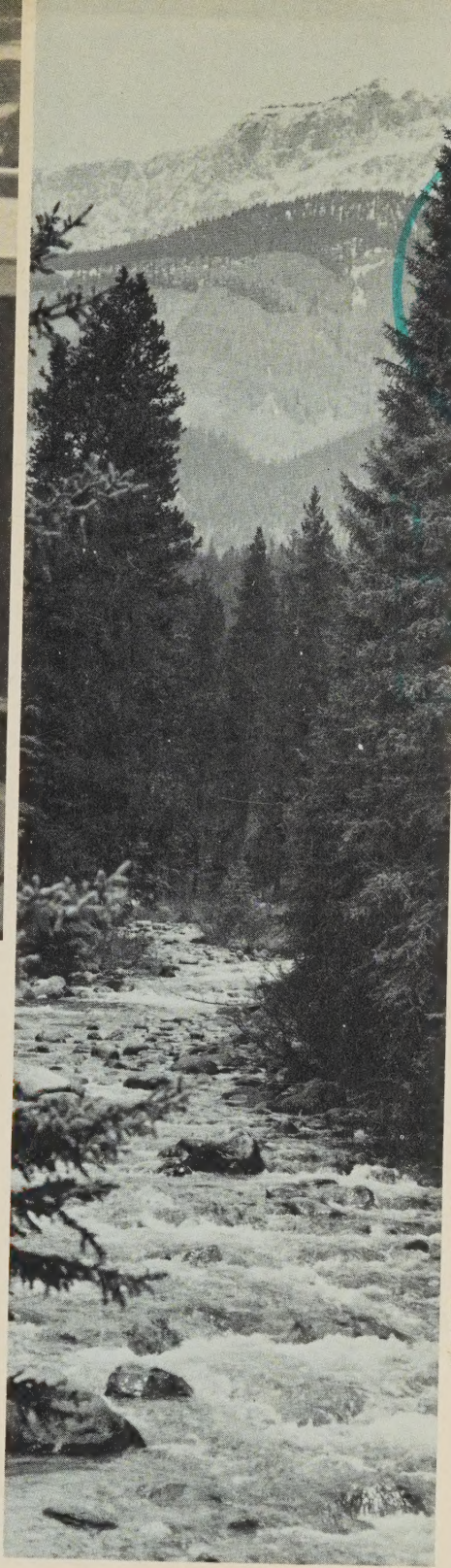
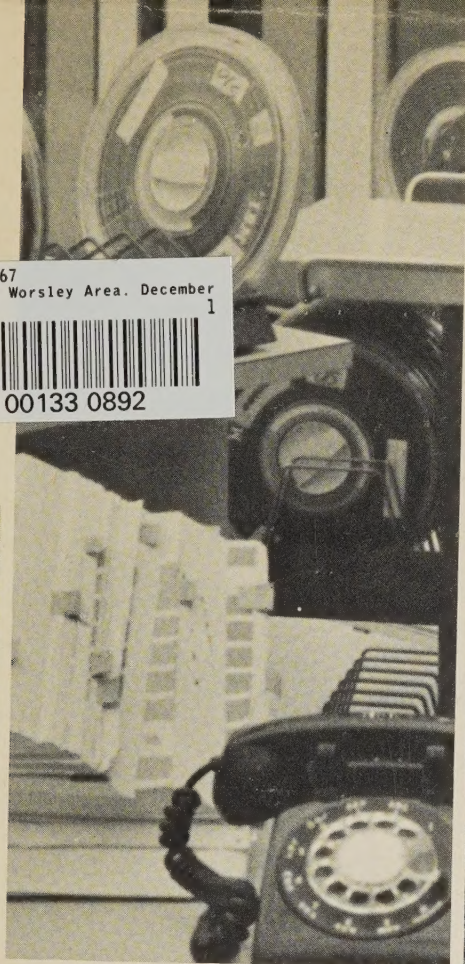


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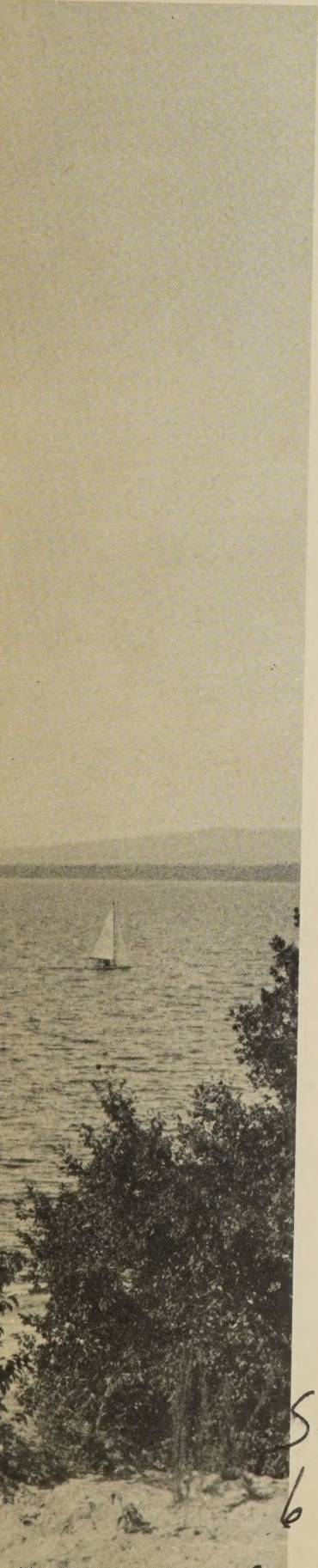
alberta
department
of the
environment

HON. W. J. YURKO, MINISTER
DR. E. E. BALLANTYNE, DEPUTY MINISTER

GROUNDWATER STUDY
WORSLEY AREA

December, 1971

EARTH SCIENCES AND
LICENSING DIVISION



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DEPARTMENT OF THE ENVIRONMENT
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GROUNDWATER STUDY
WORSLEY AREA

December, 1971

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section: O. Korsberg
G. Yamada



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ABSTRACT

This study of the Worsley area is part of a program to evaluate the groundwater resources of Alberta. Field exploration included drilling to 75 feet with an auger drill, and to 500 feet with a rotary drill in order to supplement existing information.

During drilling, gravel deposits were encountered with their base elevation at 1,960 feet. A test well was installed to evaluate the groundwater potential of these gravels. The yield was low and the water quality poor; however, it was suitable for livestock.

There are several springs at an elevation of 1,350 feet in the southwest portion of the area; their total flow being approximately 200 gallons per minute (gpm) of potable water.

The examination of structure test hole electric logs showed a deposit of gravel, 830 feet deep, with its base at an elevation of 1,225 feet. This elevation correlates closely with other deep gravels in the Peace River Region. A test well was not installed into this gravel because the depth makes it uneconomical for general rural groundwater development.

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INTRODUCTION

- General

The study of preglacial gravels in the Worsley Area is part of a province-wide groundwater inventory, development and exploration program. Methods of investigation used include: review of all available bedrock and surficial geology reports, survey of river outcrops by helicopter, spring surveys with sampling and analysis of water, interpretation of air photographs and structure test hole electric logs, and field work such as test drilling, well installation and pump tests.

Deep test hole drilling was conducted in 1967 and 1968 with a test well 226E (Figures 3, 5, 6 and 7)* installed in 1968. Results indicated the gravel and sandstone formations encountered were dry. Interpretation of structure test hole logs indicated the presence of a main channel outside the area of test drilling. The gravels encountered by drilling are considered to be terrace deposits of the main channel. The main channel is approximately 725 feet deep, which is considered too deep for economical rural groundwater development; thus no test well was installed.

- Location and area of report

The 250 square mile area, covered by this report, is located 400 miles north-northwest of Edmonton by road. It's borders are the Eureka, Clear and Peace River to the north, west and south respectively. The eastern boundary being Range 7, west of the 6th meridian.

* All figures and tables appear in Appendix A

- Physiography

The area consists mainly of a flat plain at an elevation of 2,200 feet. The surrounding river valleys have a minimum elevation of 1,200 feet. Most of the surface material is of glacial lacustrine origin, consequently, generally fine textured to a depth of 20 feet.

The Peace and Clear River valleys are approximately 1,000 and 600 feet deep respectively. The river valleys are rugged and have considerable tree cover.

GEOLOGY

A number of geology and groundwater reports have been written for the Peace River Region (refer to Figure 1). Table 1, after Green and Mellon (1967), lists the succession of strata in the Chinchaga River and Clear Hills Area. The first bedrock encountered in the area is the Kaskapau Formation, and in the deeper river valleys, the Dunvegan Formation. Both formations are Upper Cretaceous in age.

- Description of Formation (Green et. al. 1970)

-- Shaftesbury Formation

The Shaftesbury Formation underlies much of the lowland area adjacent to the Peace, Hay and Chinchaga Rivers. The unit is from 800 to 1,000 feet thick, consisting of marine dark grey to black, highly fissile shale, scattered thin bentonite beds and abundant concretionary ironstone. Thin, laminated, fish scale-bearing siltstones are present in the lower part, and a fine-grained cherty sandstone interval, 20 to 30 feet thick about 250 feet above the base of the formation, is exposed along the south flank of the Caribou Mountains. The Shaftesbury is prone to large-scale slumping in the form of landslides and mudflows, which are associated in places with spontaneous combustion of shales rich in organic matter. The upper boundary with the Dunvegan Formation appears conformable and gradational from subsurface data.

-- Dunvegan Formation

Consisting mainly of friable, pale grey, fine-grained, feldspathic sandstone with scattered hard calcareous beds, laminated carbonaceous siltstone and dark grey silty shale. Although fossil remains are scarce, the beds appear to be of deltaic origin.

-- Kaskapau Formation

Kaskapau Formation is about 500 feet thick in this area. The lower 50 to 150 feet of strata comprise a succession of fine-grained quartzose sandstone, dark grey silty shale and thin beds of ferruginous oolitic ironstone conformably overlying the Dunvegan Formation. The upper 150 to 400 feet consist of marine dark grey, silty shale gradational at the top with the overlying Bad Heart Formation.

- Quaternary

The surface deposits in the Worsley area are of lacustrine origin. Thickness of the lacustrine material is approximately 20 feet with the total thickness of till reaching a maximum of 830 feet in the main preglacial river valley. Tokarsky, (1969, p. 34) measured 21.5 feet of lacustrine deposits with 108 sets of varves at NE9-82-24-W5 (elevation 1,900 feet). He also mentions a maximum thickness of 62 feet for lacustrine deposits, with thinning on shore lines in the Cardinal Lake-Grimshaw area. Marciniuk and Kerr, (1970) in the Manning area encountered 20 feet of lacustrine deposits with an upper elevation of 1,500 feet.

INVESTIGATION

This investigation was conducted as part of a province-wide buried channel program of the Soils, Geology and Groundwater Branch, Water Resources Division. Ten shallow holes were drilled from 1966 to 1969. Preliminary investigations showed that deeper gravels might be present; thus drilling to 500 feet was started in 1967. Using a CFD-1 drill, two holes were drilled in 1967, with three test holes and a test well in 1968. Springs in the area were sampled and surveyed in 1968 and

an inspection of river cuts by helicopter in 1969. Interpretation of 12 structure test hole electric logs were also included in the final preparation of this report.

RESULTS

- General

Bedrock was encountered within 280 feet in all Water Resources holes. Approximately 50 feet of gravel was encountered immediately above the bedrock contact. A well, constructed to a depth of 512 feet, yielded less than 1 gpm during testing. Two springs discharging at 100 gpm on the west side of the area indicates that water occurs in the gravel.

A deeper gravel deposit was found from examination of structure test hole electric logs with its lowest elevation being 1,225 feet. This elevation correlates with other deep preglacial gravels in the Peace River Region as shown in Figure 4. The groundwater potential of the deepest gravel is not known; however, from consideration of the gravel elevation and electric logs, indications are that large supplies of groundwater are available.

- Map of correlation of deepest (glacial or preglacial) gravel and present day Peace River elevations

Figure 4 was prepared to determine if a relationship exists between the gradient and elevation of the present day Peace River and that of the deepest gravels found in the area.

The source of data was topographic maps, various reports, structure test hole data and current test drilling. The elevation of preglacial

gravels in British Columbia was taken from a report by Mathews, (1963). Additional information was obtained from structure test hole electric logs in the Worsley area, deepest gravel elevation in the Peace River town area from reports by Tokarsky, (1969), and Henderson, (1959), and Water Resources test drilling in the Manning area.

- Test Well - Hole 226E

Preliminary testing during drilling and the examination of electric logs from other test holes indicated that the possibilities of developing a water supply were poor. However, due to the presence of gravel between an elevation of 1860 and 1900 feet and sandstone sections, one test well was installed (Figure 5).

-- Pump Test No. 1

Casing with a five foot section of screen was set at the base of the gravel, at a depth of 172 feet, and then developed with a compressor. The well was then blown out completely and left over-night. The static level was 166 feet in the morning with no water obtained during pumping from 163 feet.

-- Pump Test No. 2

Casing was then removed and drilling resumed. A slight circulation loss was noted at 265 feet with complete circulation loss at 292 feet. The water level dropped immediately to 230 feet and was 257 feet three hours later. Casing was installed to 265 feet and the hole then drilled to 395 feet. Compressor pump testing was conducted for two hours with no measurable yield. Water level measurements below 300 feet were not obtained due to equipment malfunction. However, the water level was measured at 291 feet 90 minutes after testing.

-- Pump Test No. 3

The test well was completed to a depth of 500 feet, electric logged and blown out with the compressor. Again, no measurable yield. Fifteen days later the water level was measured at 410 feet.

- Springs

On the east bank of the Clear River numerous springs were encountered. The combined flow of the springs was approximately 250 gpm. This is due primarily to two 100 gpm springs which were discharging from the gravels in the vicinity. The water is hard and high in sulfates. From examination of profile No. 2 the water discharges from a gravel bed which is close to the elevation of deepest gravel in the area. Refer to Table 2 for detailed water analysis.

- Profiles

-- Profile No. 2

This profile includes the Water Resources test well and test holes and several structure test hole electric logs. The location of all holes is shown in Figure 3. The deepest gravel is clearly visible on electric logs 9 and 10. The self-potential and resistivity logs indicate good quality water which should be similar to the spring in LSD 3-4-84-11-W6. The gravel outcrop at that location (the Clear River) coincides in elevation with deepest gravel of logs 9 and 10. This spring is discharging at approximately 100 gpm from the gravel at this location. It appears that the preglacial Peace River followed the present Eureka and Clear Rivers, going westward from the structure test holes.

-- Profile No. 2

The location of this profile is slightly east of profile No. 1. The

deepest gravel is clearly visible in electric logs 1 and 3.

Test well 226E is in a gravel deposit which is at a relatively high elevation when compared to present day river valleys. The high elevation probably causes discharge in the form of springs along river banks.

CONCLUSION AND RECOMMENDATIONS

The occurrence of springs and seepages from gravels on the east bank of the Clear River (west side of study area) indicates there is considerable infiltration of water and thus recharge to groundwater in the vicinity, nevertheless most shallow gravel deposits will be unsaturated because water is discharged from the outcrops.

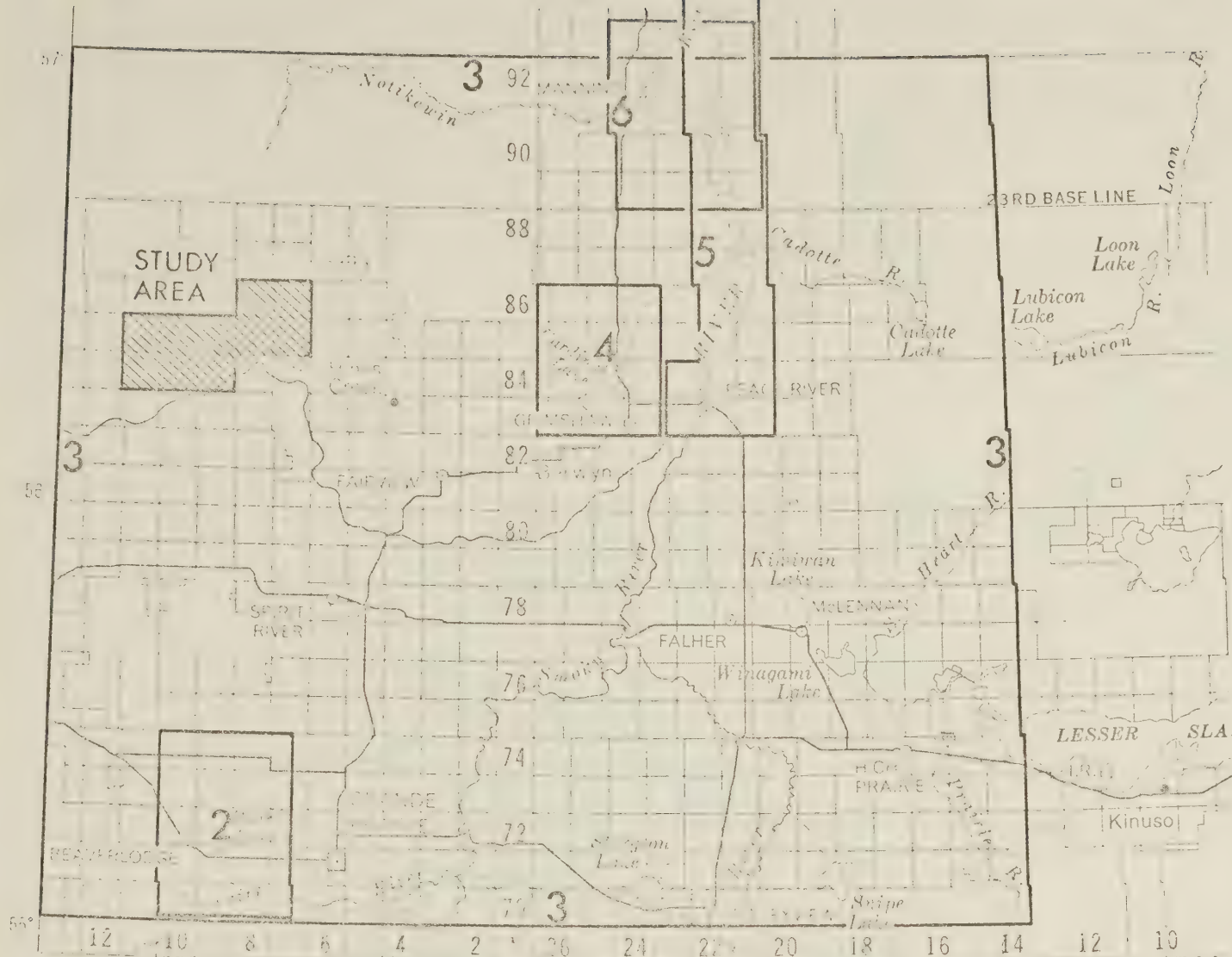
The structure test hole electric logs were useful in the location of the deepest gravel, indicating the preglacial river elevations in the Peace River area. It is planned to publish, by March, 1973, electric logs and profiles to substantiate the information presented in Figure 4.

The deep gravel was not investigated for groundwater during this study. However, the depth of this gravel (800 feet) generally rule out economic development for domestic use. We thus recommend a surface supply of water for domestic use.

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APPENDIX A



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5. Wickendon, R.T.D. 1951 Some Lower Cretaceous Sections on Peace River below the Mouth of Smoky River, Alberta, G.S.C. Paper 51-16.
5. Green, R., Mellon, G.B. and Carrigy, M.A. 1970 Bedrock Geology of Northern Alberta , R.C.A. Edmonton, Alberta .
6. Marciniuk, J. and Kerr, H.A. 1971 Preglacial Channel Groundwater Study Manning Area. Alberta Department of Agriculture Report, 1971 .

FIGURE 1.

INDEX MAP OF STUDY AREA

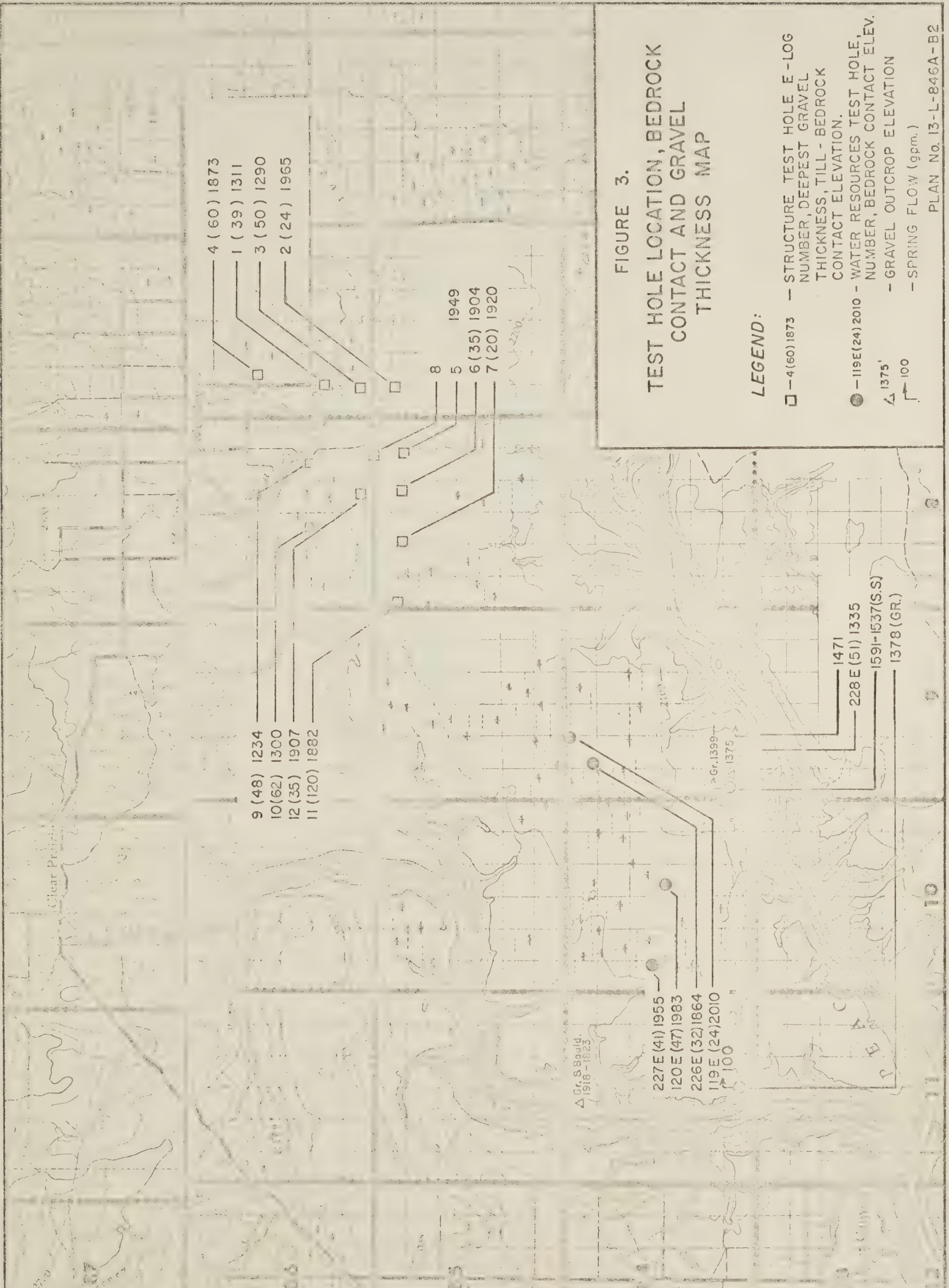
PLAN No. 13-L-846A-B1



- FIGURE 2.

AFTER GREEN *et al*
1970, R.C.A.

PLAN No. 13-L-846A-EI



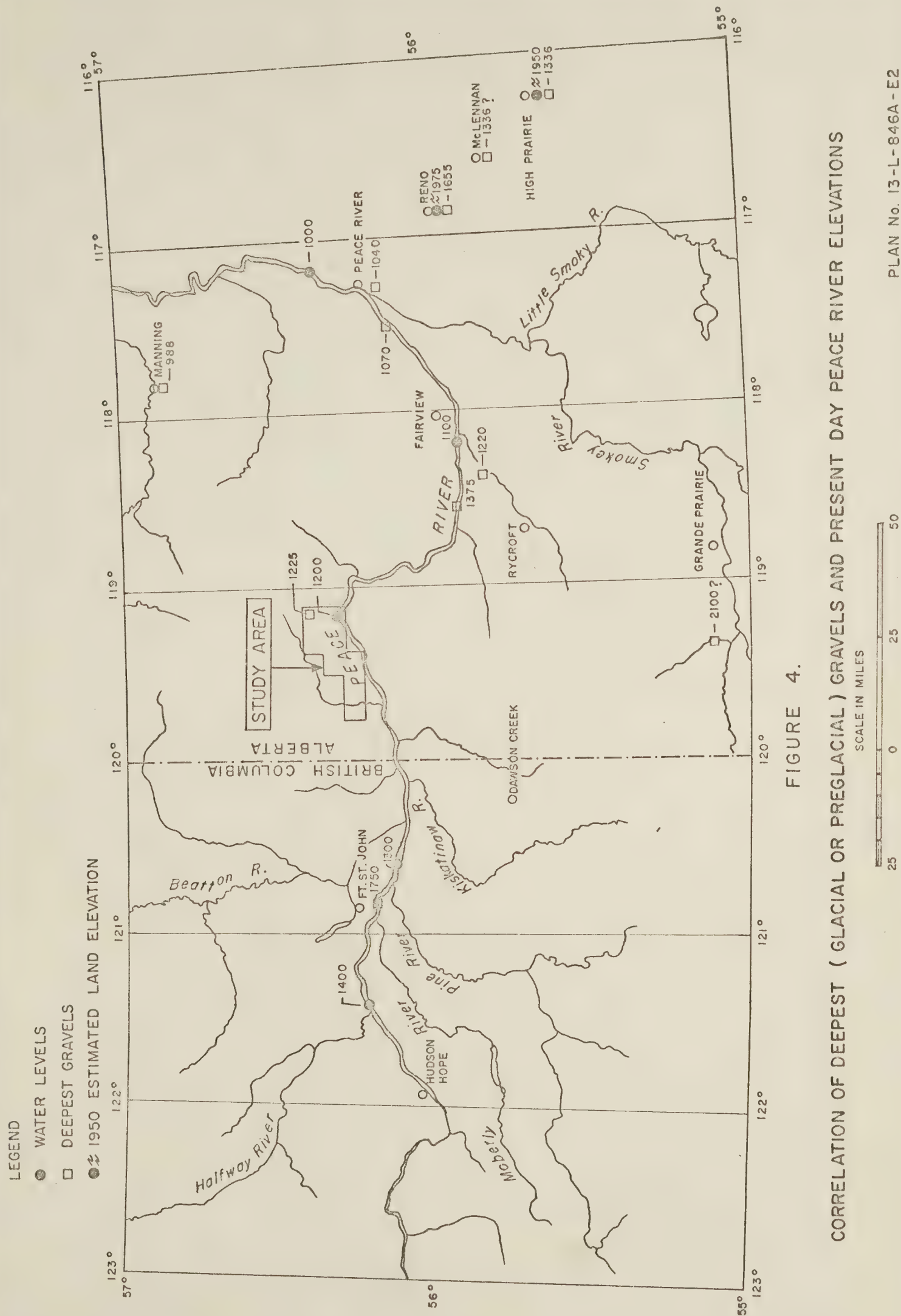
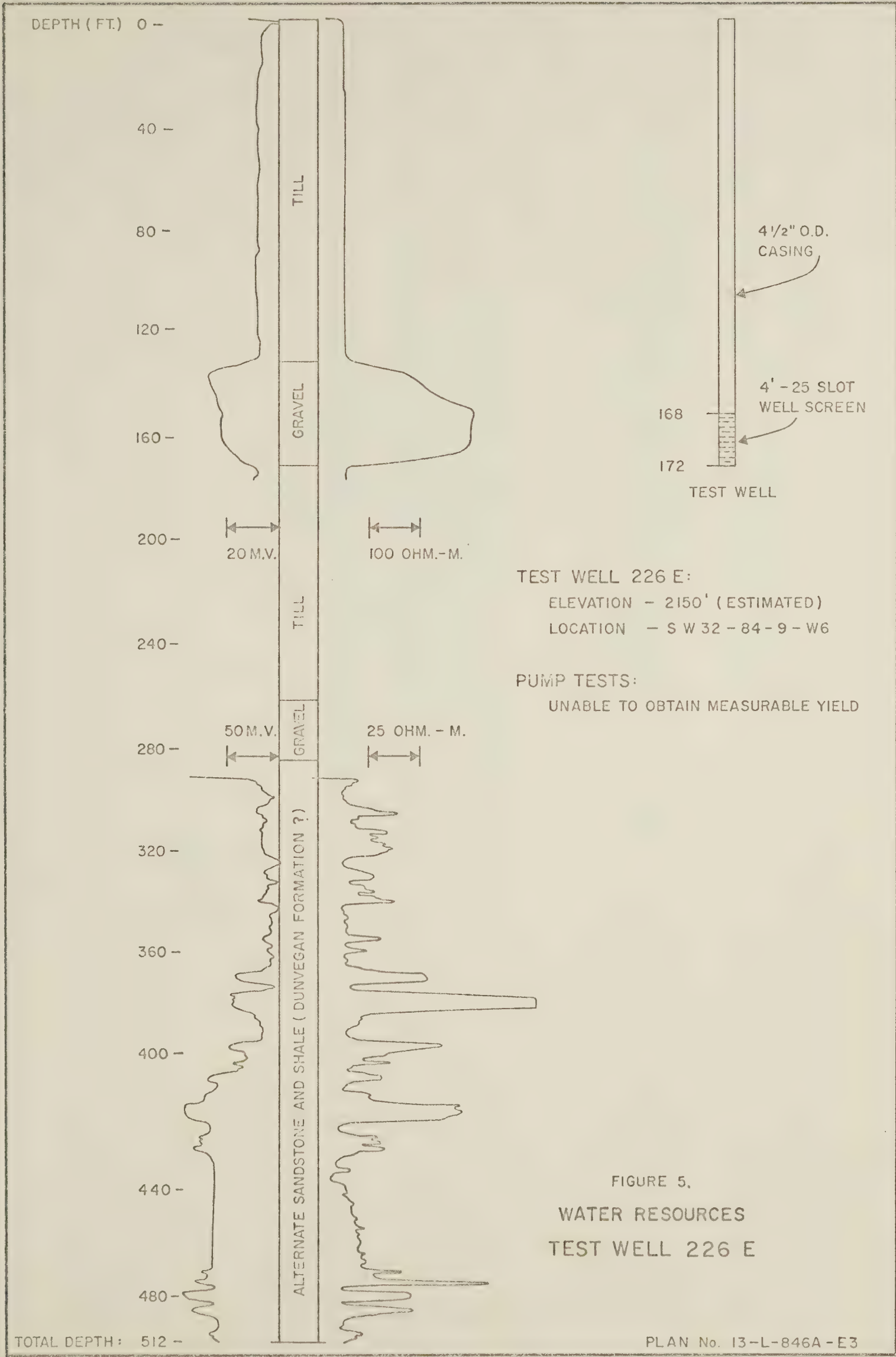
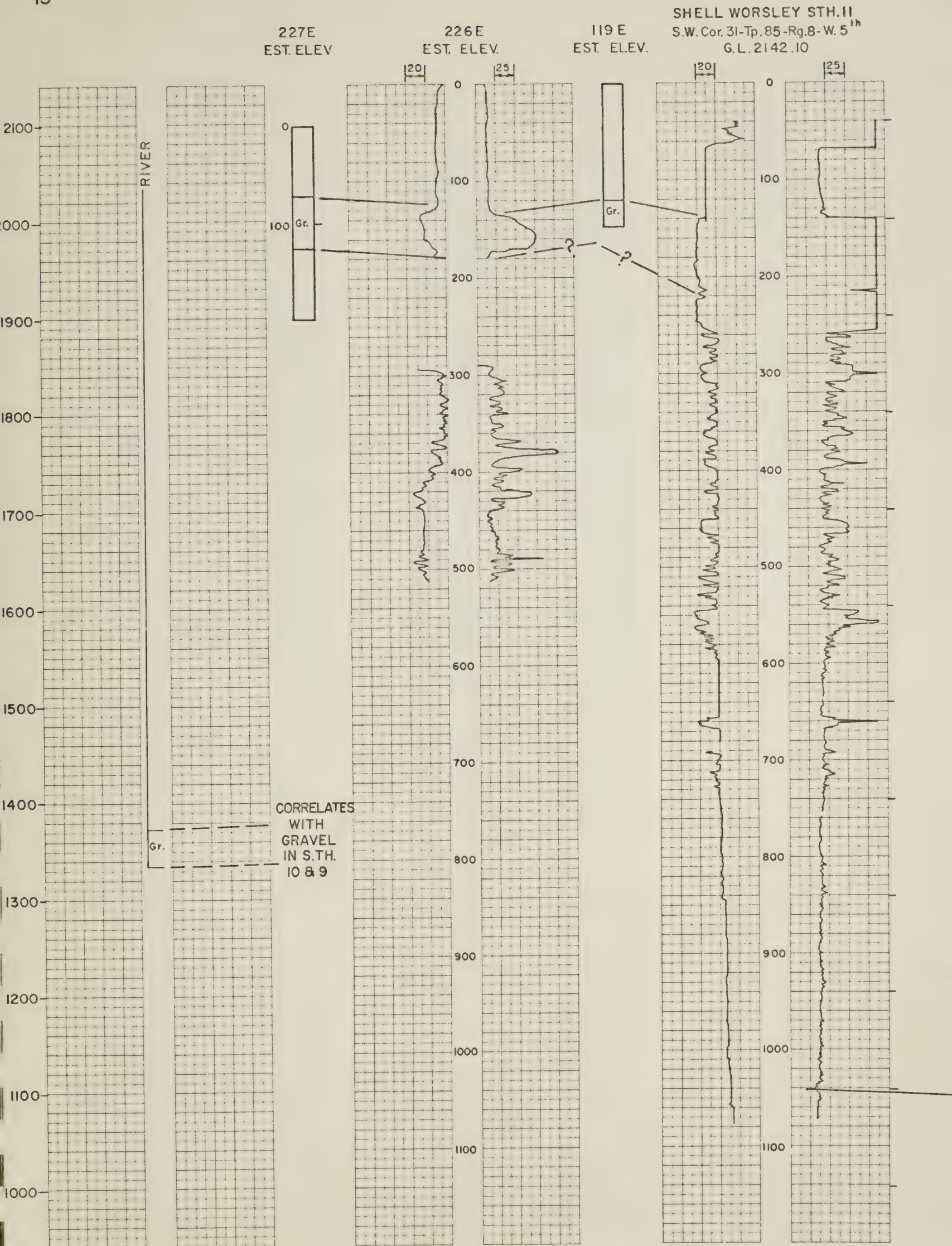


FIGURE 4.

CORRELATION OF DEEPEST (GLACIAL OR PREGLACIAL) GRAVELS AND PRESENT DAY PEACE RIVER ELEVATIONS

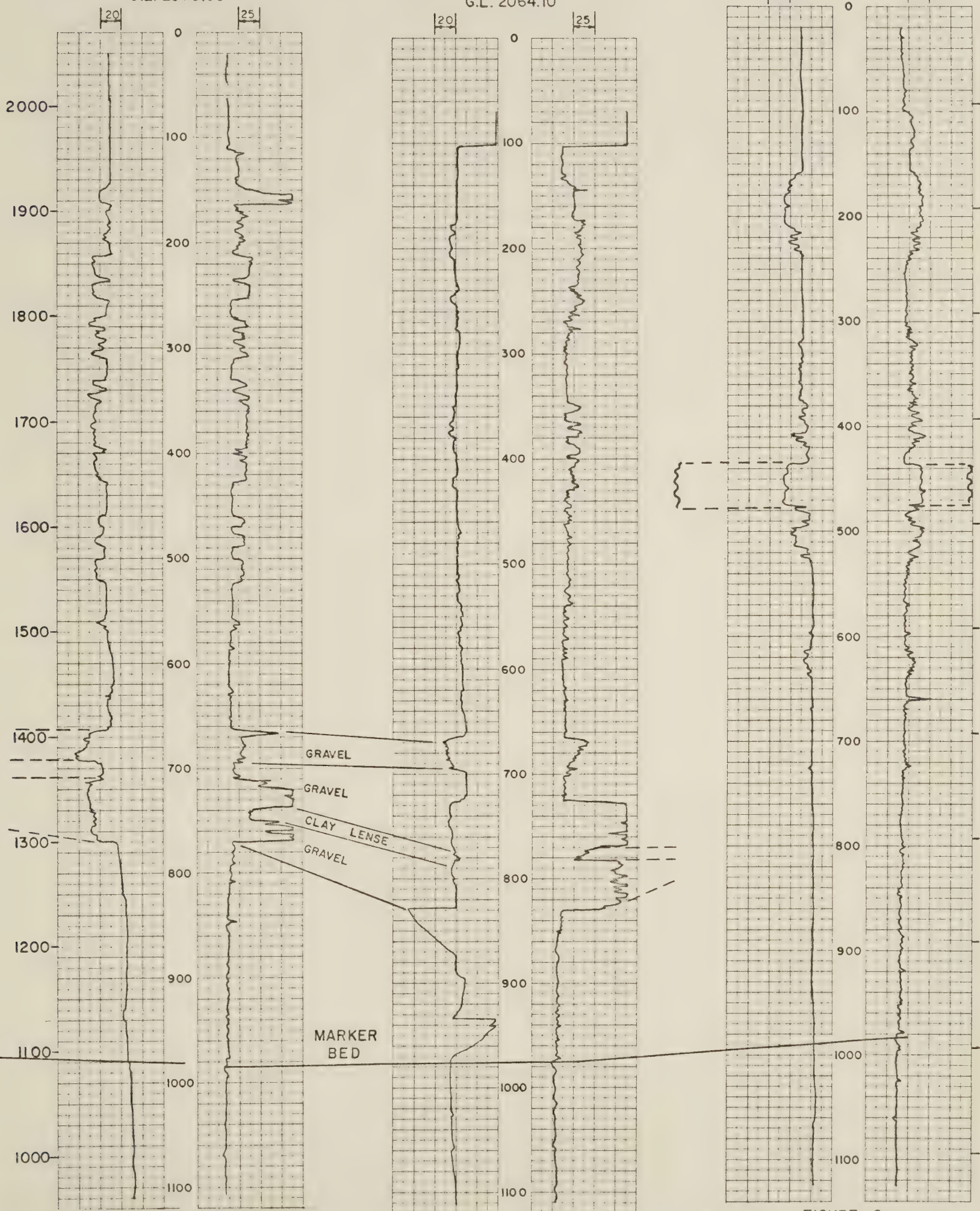




SHELL WORSLEY STH. 10
2000'W, S.E. Cor. 16-Tp. 86-Rg. 8-W. 5th
G.L. 2070.00'

SHELL WORSLEY STH. 9
3000'W, S.E. Cor. 14-Tp. 86-Rg. 8-W. 5th
G.L. 2064.10'

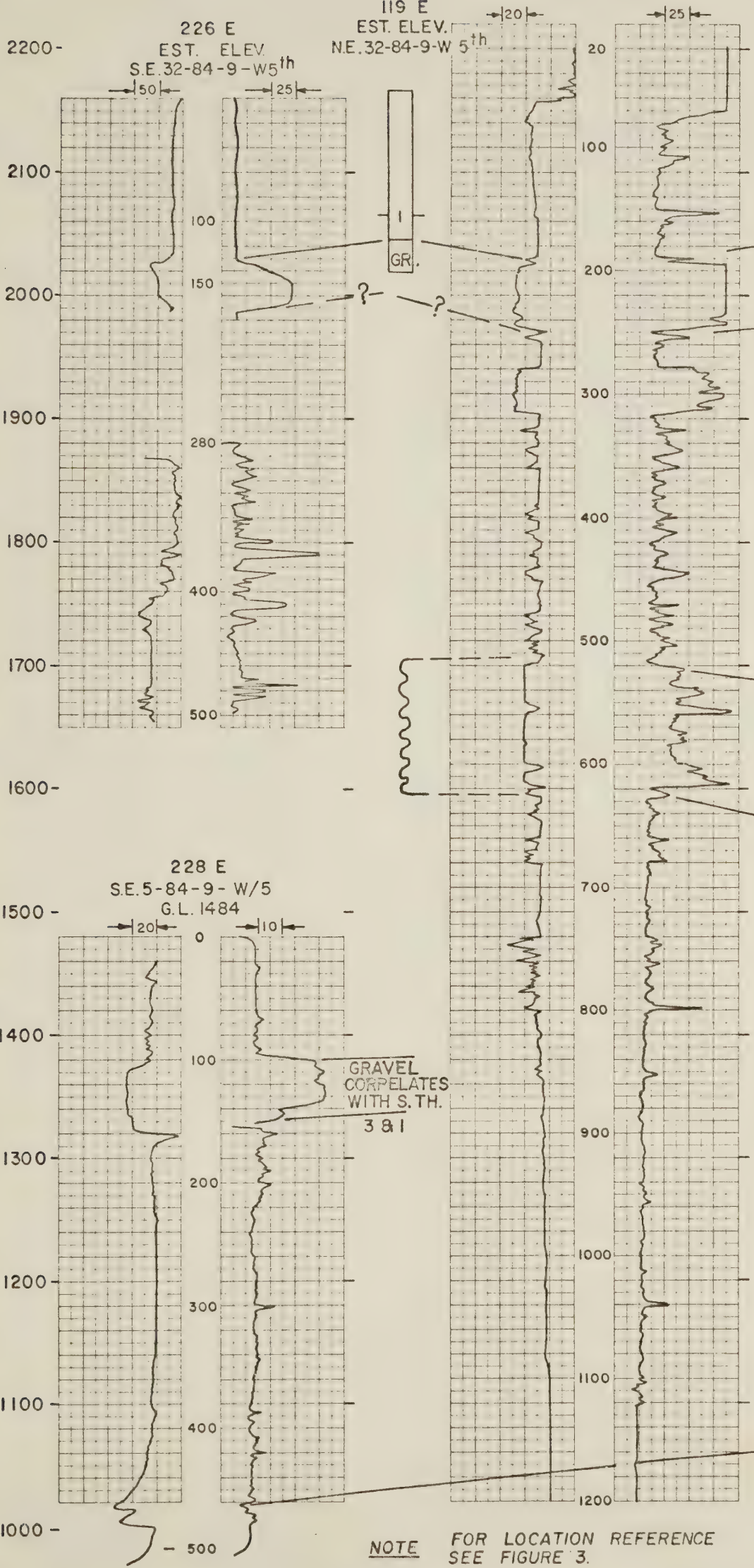
SHELL WORSLEY STH. 4
4000'N, S.E. Cor. 19-Tp. 86-Rg. 7-W. 5th
G.L. 2093.70'



NOTE FOR LOCATION REFERENCE
SEE FIGURE 3.

FIGURE 6
PROFILE NO. 1
PLAN No. 13-L-846A-E4
PLAN No. 13-L-846A-E4

SHELL WORSLEY STH. 6
2000' W S.E. Cor. 34-85-8-W5th
G.L. 2219.50



SHELL WORSLEY STH. 5
1000' W S.E. Cor. 35-85-8-W5th
G.L. 2159.90

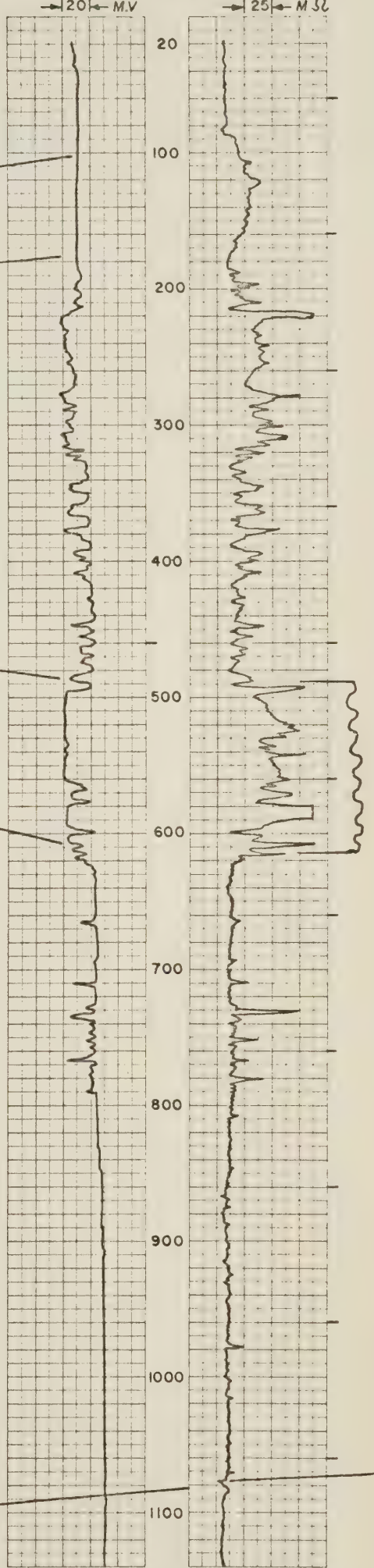
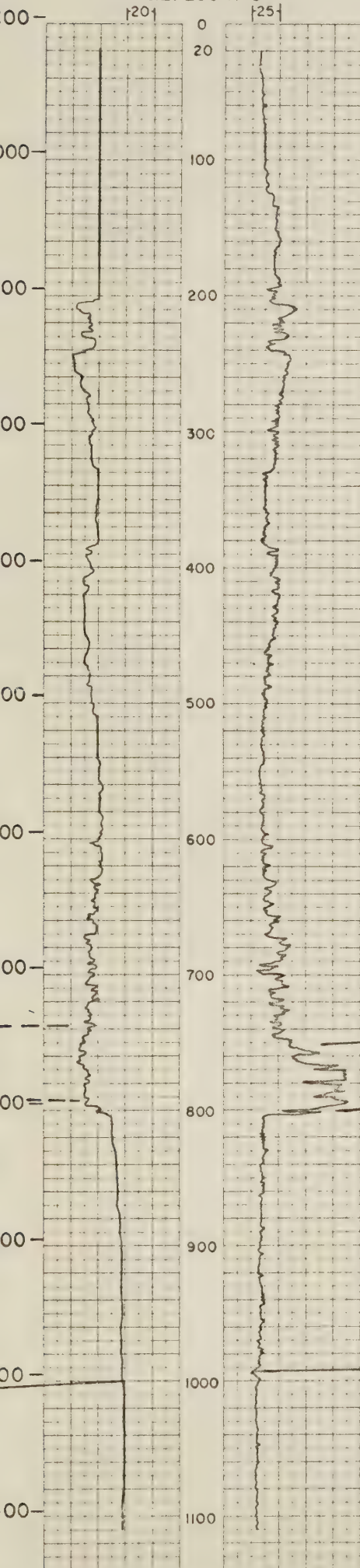


FIGURE 7

SHELL WORSLEY STH. 3

S.E. Cor. 6, Tp. 86, Rg. 7, W. 5th.

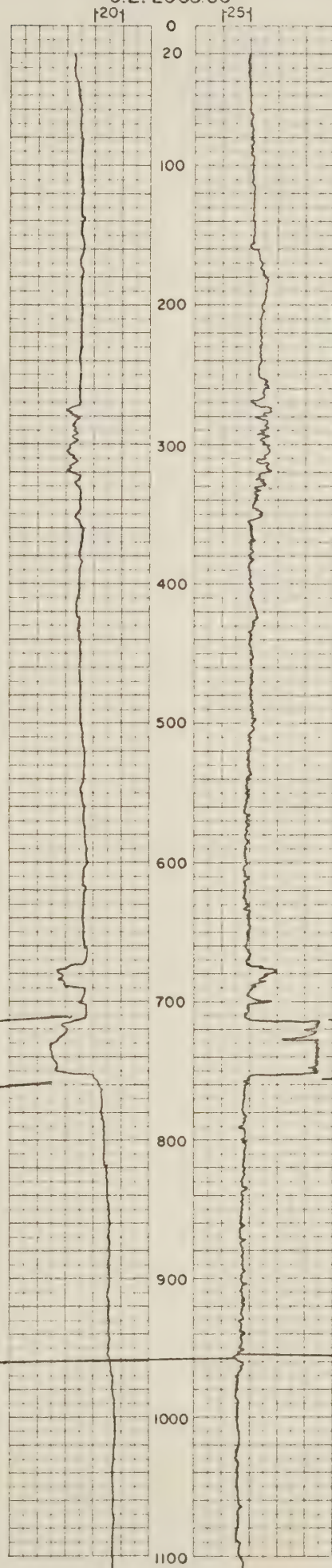
G.L. 2094.75'



SHELL WORSLEY STH. 1

2000' N. S.E. Cor. 7, Tp. 86, Rg. 7, W. 5th.

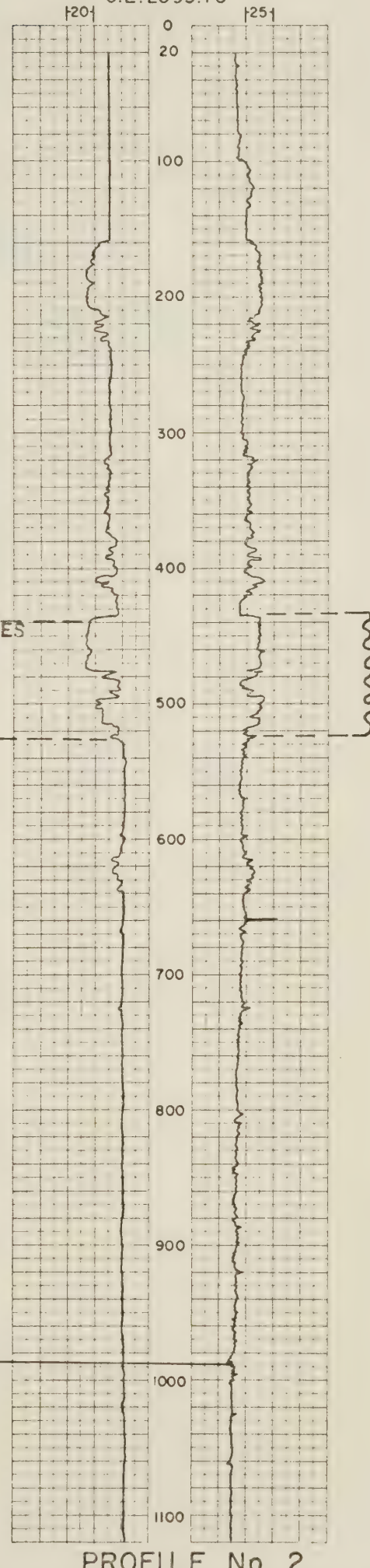
G.L. 2065.60'



SHELL WORSLEY STH. 4

4000' N. S.E. Cor. 19, Tp. 86, Rg. 7, W. 5th.

G.L. 2093.70'



PROFILE No. 2

PLAN No. 13-L-846A-E5

Table 1. Succession of Strata in the Chinchaga River and Clear Hills area (after Green and Mellon, 1962)

AGE		Rock Unit		Thickness (feet)	Lithology	
Tertiary		Glacial and river deposits		0-800	Boulders, gravel sorted & unsorted till	
Cretaceous	Upper	Wapiti Formation		0-400	soft, whitish sandstone; grey, blocky, carbonaceous shale; thin coal seams	
		Smoky River Group	Puskwaskau Formation		300-600	dark grey, fissile shale
			Bad Heat Sandstone		0-30	green, ferruginous, oolitic sandstone and mudstone
			Kaskapau Formation	upper member	150-410	dark grey, fissile shale
				lower member	40-155	whitish sandstone; grey sandy shale; oolitic siderite
		Dunvegan Formation		500-775	soft, grey sandstone with calc. concretions; grey silty, carbonaceous shale	
		Shaftesbury Formation		upper member	300-550	grey, silty shale; thin laminated siltstone
	Lower			lower member	600-1050	black, fissile shale; numerous fish scales

Table 2. Water analysis from study area in parts per million.

	Alberta Limits	Spring LSD3-4-84- 11-W6	Spring LSD2-5-84- 9-W6	Spring LSD10-6-84- 9-W6	Test Well 226-E SW32-84- 9-W6
Total Solids	1000	760	1280	1624	2168
Ignition Loss		190	166	228	360
Hardness	500	449	308	455	13
Sulphates (SO_4)	500	243	248	700	815
Chlorides	250	8	10	4	2
Alkalinity	500	352	835	550	575
Nature of Alkalinity		(1)	(1.1)	(1.1)	(1.1)
Nitrite Nitrogen		nil	nil	trace	nil
Nitrate Nitrogen (N)	+10	nil	nil	1.0	nil
Iron	0.3	0.10	0.89	5.40	125
Fluoride	1.5	0.34	0.23	0.73	
Soda		? 39.1 grains/gal.		?	
REMARKS		(2)	(2.1)	(2.1)	(2.2)

(1) Bicarbonate of Lime and Magnesium

(1.1) Bicarbonate of Soda, Lime and Magnesium

(2) Water is Chemically Suitably

(2.1) No. 2 After Iron settles

(2.2) Water Chemically Unsuitable

NOTE: All samples reported on August 8, 1968

Table 3. International Standards of Drinking Water, World Health Organization (1958); Chemical Quality (1).

		Permissible (ppm)	Excessive (ppm)
Total Solids		500	1500
Iron	Fe	0.3	1.0
Manganese	Mn	0.1	0.5
Copper	Cu	1.0	1.5
Zinc	Zn	5.0	15.0
Calcium	Ca	75	200
Magnesium	Mg	50	150
Sulphate	SO ₄	200	400
Chloride	Cl	200	600
MgSO ₄ + Na ₂ SO ₄		500	1000

Table 4. Upper Limit of Dissolved Solids Concentration in Water To Be Consumed by Livestock, after Hem (1959), (2).

Livestock	Concentration (ppm)
Poultry	2860
Pigs	4290
Horses	6435
Cattle (dairy)	7150
Cattle (beef)	10000
Adult sheep	12900

(1) World Health Organization (1958): International Standards of Drinking Water. World Health Organization, Geneva.

(2) Hem, John D. (1959): Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geol. Surv., Water Supply paper 1473.

Table 5. Worsley Area Domestic Test Hole Data.

Township 84 Range 10 West 6th

SE 10 Hole No. 570-H

0 - 1	CL ⁽¹⁾	sm ⁽²⁾
1 - 8	C	m
8 - 18	C	m
19 - 25	SiC	m
25 - 35	C	m
35 - 58	SiC	sm
58 - 75	C	sm

NW 11 Hole No. 569-H

0 - 1	SiCL	sm
1 - 8	SiC	m
8 - 20	Cl	m
20 - 37	SiC	m
37 - 75	C	sm

NW 12 Hole No. 5596-C

0 - 3	SiCL	0 - 9	Dry
3 - 11	SiC	9 - 57.5	sm
11 - 70	C	57.5 - 70	Dry

S½ 22 Hole No. 5595-C

0 - 3	SiCL	0 - 25	m
3 - 13	SiC	25 - 30	sm
13 - 30	C	30 - 52.5	Dry
30 - 30.5	Gravel & Boulders	52.5 - 70	sm
30.5 - 70	C		

(1) C = Clay
 L = Loam
 Si = Silty or Silt
 S = Sand
 sh = Shale
 ss = Sandstone
 SLTST = Siltstone

(2) m = moist
 sm = slightly moist

NE 15 Hole No. 120-E

0 - 20	SiC
20 - 95	C
95 - 142	Gravel
142 - 210	Si
210 - 212	Hard ss
212 - 232.5	SLTST
232.5 - 234	Sandy sh
234 - 323	SLTST
323 - 333	ss
333 - 335	SLTST
335 - 348	ss
348 - 367.5	SLTST
367.5 - 380	ss
380 - 388	SLTST
388 - 392	ss
392 - 395	SLTST
395 - 417	ss
417 - 420	SLTST
420 - 425	ss
425 - 500	Hard SLTST

NE 34 Hole No. 5592-C

0 - 2	SiCL	0 - 1	m
2 - 7	SiL	1 - 3	very m
7 - 9	SiCL	3 - 5	m
9 - 11	SiC	5 - 9	very m
11 - 42	C	9 - 20	m
42 - 43	gravel & Boulders	20 - 42	sm
43 - 70	C	42 - 43	Dry
		43 - 47.5	sm
		47.5 - 70	Dry

Township 84 Range 11 West 6thS $\frac{1}{2}$ 11

0 - 1	SiL	very m
1 - 3	SiCL	sm
3 - 7	SiC	m
7 - 21	C	m
21 - 24	SiC	m
24 - 65	C	sm

SW 24 Hole No. 5590-C

0 - 1	SiL	very m
1 - 2	SiCL	1 - 4 slightly m
2 - 14	SiC	4 - 25 m
14 - 32.5	C	25 - 32.5 slightly m
32.5 - 33	gravel	dry
33 - 70	C	slightly m

Township 85 Range 10 West 6th

NW 4 Hole No. 568-H

0 - 1	SiCL	sm
1 - 8	SiC	sm
8 - 12	C	m
12 - 22	SiC	m
22 - 30	clayey silt	m
30 - 45	clayey silt	sm
45 - 70	C	sm

Township 85 Range 7 West 6th

SW 3 Hole No. 4779-C

0 - 3	SiCL	sm
3 - 7	SiC	sm
7 - 32	C	m
32 - 57	SiC	m
57 - 69	Si To SiC	m
69 - 75	SiC	m

Township 87 Range 7 - West 6th

SW 1 Hole No. 471-H

0 - 1	L	m
1 - 3	SiCL	Dry
3 - 9	C	Dry
9 - 17	SiC	slightly moist
17 - 25	C	sm
25 - 35	SiC	sm
35 - 75	C	sm

SW 10 Hole No. 474-H

0 - 1	L	sm
1 - 4	SiC	sm
4 - 8	C to Si	sm
8 - 75	C to SiC	sm

NW 28 Hole No. 5586-C

0 - 1	SiCL	m	
1 - 3	SiC	3 - 12	very moist
3 - 70	C	12 - 55	sm
		55 - 70	dry

Township 87 Range 8 West 6th

SW 4 Hole No. 472-H

0 - 1	L	m
1 - 4	SiC	sm
4 - 35	C	sm
35 - 75	C to SiL	m

NE 14 Hole No. 475-H

0 - 1	CL	Saturated
1 - 45	C	sm
45 - 58	gravely till	sm
58 - 75	Mudstone	dry

Township 87 Range 10 West 6th

NW 15 Hole No. 473-H

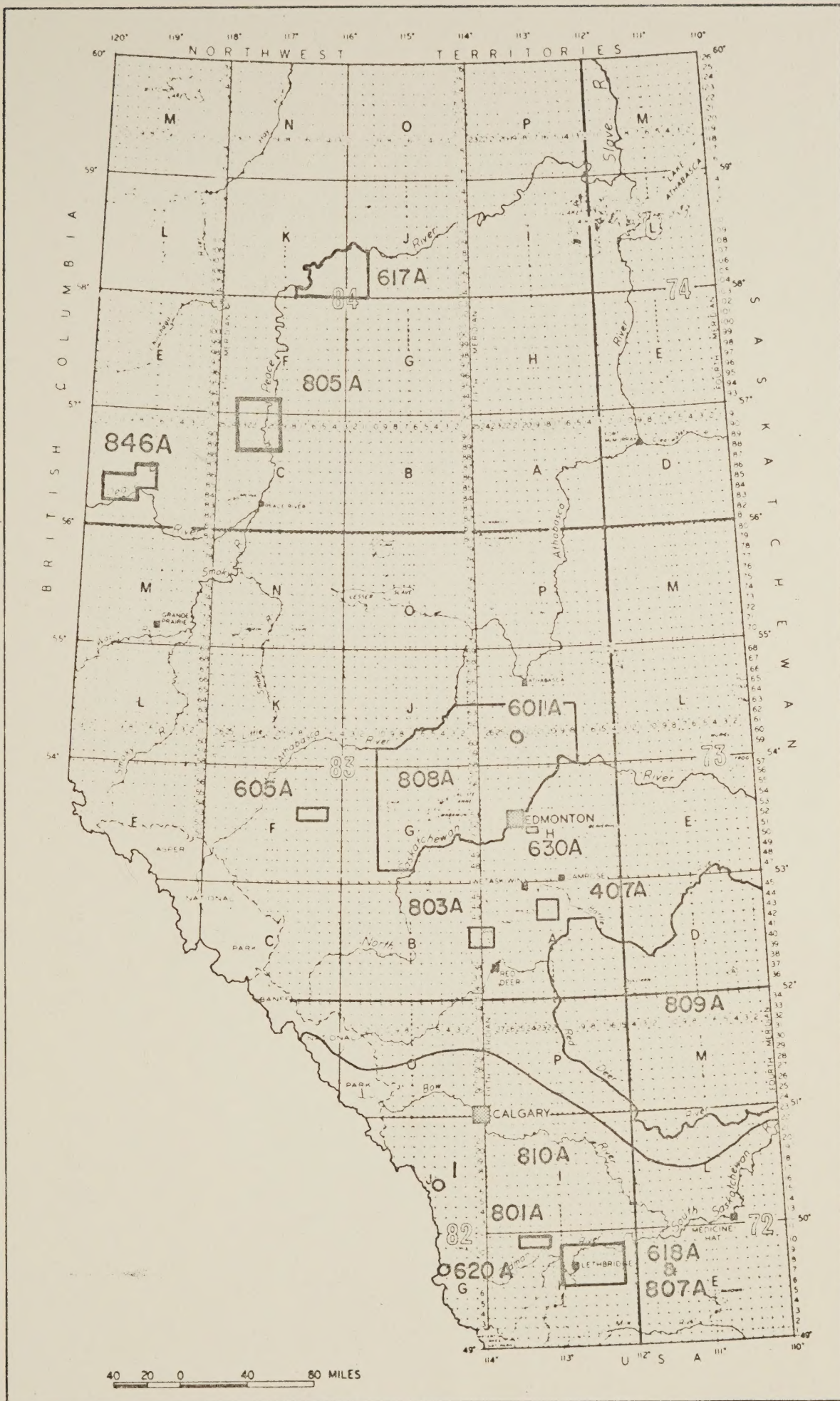
0 - 1	CL	m
1 - 8	C to SiC	sm
8 - 43	C	sm
43 - 75	Coarse sand	dry

NW 26 Hole No. 5588-C

0 - 1	L	0 - 3	dry
1 - 2	SiCL	3 - 7	sm
2 - 6	CL	7 - 24	m
7 - 24	C	24 - 30	dry
24 - 25	Medium S.	30 - 32.5	m
25 - 27.5	Coarse S.	32.5 - 35	very moist
27.5 - 45	Medium S.	35 - 76	saturated
45 - 55	Medium S. to fine sand		
55 - 62.5	loamy fine sand		
62.5 - 67.5	fine sandy L		
67.5 - 70	fine sandy L to L		

SW 34 Hole No. 5587-C

0 - 1	L	m	
1 - 2	fine sand	1 - 3	dry
2 - 3	L	3 - 6	very m
3 - 4	SiCL	6 - 8	saturated
4 - 5	CL	8 - 19	very m
5 - 6	fine sandy L	19 - 35	m
6 - 7	fine sand	35 - 39	very m
7 - 10	CL	39 - 42	saturated
10 - 12	Sandy CL	42 - 45	very m
12 - 16	CL	45 - 47.5	m
16 - 35	C	47.5 - 57.5	very m
35 - 39	CL	57.5 - 70	m
39 - 42	loamy fine sand		
42 - 47.5	Si		
47.5 - 60	CL		
60 - 70	L		



LIMITED CIRCULATION REPORTS

PLAN No. I3-L-846A-B3

